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Lumber Value Loss Associated with Tapping Sugar Maples for Sap Production

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Abstract

Tapping sugar maples for sap production yields an annual income, but there is a loss in timber quality if the tree is cut for factory lumber products. We estimate an average loss per tree of $2.87 based on a sample of 90 trees in Vermont that were formerly tapped.

ODC 852.19 : 892.68 : 176.1 *Acer saccharum* Marsh.

Tapping of sugar maple for sap production damages the wood in the vicinity of the tapholes. This damage has been characterized, and the tree's response to this kind of wounding has been studied (Walters and Shigo 1978). Although tapping for sap production yields an annual income, there is a loss in timber quality if the tree is cut for factory lumber products. We have developed a method to estimate the value of this quality lost.

Methods

Data used in this analysis were collected in 1975 for the purpose of comparing lumber-grade yield distributions from logs cut from sugar maple used for sap production with yields from forest-grown sugar maples as reported by Vaughan and his coworkers (1966).

Four former sugarbushes were selected in northwestern Vermont on the basis of the owner's willingness to cut. A sugarbush may be defined as part of a stand of mature hardwood forest where most other trees have been cut and the maples have been thinned sufficiently to allow trees to develop a good crown growth (Willits and Hills 1976). The smallest scale recognized for commercial maple syrup production is 500 taps, which may cover an area of 5 to 7 acres (Willits and Hills 1976).

Merchantable trees in the four sugarbushes were selected for cutting: sugarbush 1—17 trees, sugarbush 2—19 trees, sugarbush 3—12 trees, and sugarbush 4—42 trees. They were scanned with a portable metal detector from stump height to about 10 to 12 feet above ground level. Trees that contained no detectable metal (overgrown spouts) were cut using local cutting practices and skidded to a landing. Ninety trees were cut and bucked for grade, and the logs were graded according to USDA Forest Service log grades (Rast et al. 1973).

The logs were transported to a local sawmill where the butt logs were again electronically scanned for overgrown metal. All logs were sawed into lumber and timbers; each piece was marked with the number of the parent log so individual trees could be reconstructed for analysis. The lumber was graded according to National Hardwood Lumber Association inspection rules using a double grading technique. The first grading ignored the holes and stain caused by tapping; then, the lumber was regraded recognizing these defects. These grade-yield differences comprise the basic data for this analysis.

The mill tally of board-foot volumes by lumber-grade—Firsts and Seconds, Selects, No. 1 Common, No. 2 Common, No. 3A and No. 3B Common and Timbers—was determined for each tree. Each tree had two sets of volume data: one showed volume by lumber grade ignoring taphole damage, and the other recognized taphole damage.

In computing tree value, we modified the quality index system developed by Herrick (1946). Quality index is a number that expresses the relative value of a tree as a function of the amount and value of the different grades of 4/4 lumber that can be sawed from it. Values were applied by the use of price relatives (PR) (Herrick 1956), which were derived from the 1975 to 1980 *Hardwood Market Report*. Prices for each lumber grade were averaged for the 5-year base period (mid-1975 to mid-1980) and expressed as a proportion of the average price for No. 1 Com-

mon Lumber (Table 1). The tree value formula is:

$$\text{Tree value} = [(\text{FAS} \times \text{PR}_{\text{FAS}}) + (\text{Sel} \times \text{PR}_{\text{Sel}}) + \ldots + (\text{Timbers} \times \text{PR}_{\text{Timbers}})] \times \text{Price/Bf}$$

Where:

FAS is the total volume of lumber sawed from the tree that would grade Firsts and Seconds.
PR_{FAS} is the price relative for FAS lumber.
Price/Bf is the current price of No. 1 Common 4/4 hard maple lumber in dollars per board foot.

Table 1.—Price relatives for hard maple lumber and timbers[a]

Lumber grade	Price relative[b]
Firsts and seconds	1.32
Selects	1.24
No. 1 Common	1.00
No. 2 Common	.66
No. 3A Common	.58
No. 3B Common	.45
Timbers	.50

[a] Northern Hardwoods (F.O.B. Mills—Wausau, Wisconsin Area) hard maple 4/4 lumber and hardwood hearts from 1975–80 *Hardwood Market Report*.

[b] Prices for all grades expressed as proportion of price for No. 1 Common lumber.

Two estimates of tree value were made for each tree: one ignored tapholes and associated stain; the other recognized tapholes and stain as defects. The second estimate subtracted from the first is the tree value loss in dollars attributable to tapping for sap production.

Dollar values in this report are based on the current value of $274 per thousand board feet for No. 1 Common 4/4 hard maple lumber. These dollar values can be easily adjusted to reflect a current lumber price (C) by multiplying all values by C ÷ 274. When there is a major shift in the relative prices among grades, it is necessary to recompute values using the tree value formula.

Results and Discussion

Of the 90 trees in the analysis, 37 had factory grade-1 butt logs, 39 had grade-2, and 14 had grade-3. Each tree grade was assumed to be equivalent to its butt-log grade. The average volume from the mill tally was 247.6 board feet, and average lumber value was $57.94 for trees not tapped, and $54.99 for those tapped. Table 2 shows mean dbh, merchantable height, and butt-log grade by sugarbush.

Table 3 shows the mean value loss per tree. Mean value loss ranged from $.68 per tree in sugarbush 2 to $4.39 in sugarbush 3. The loss values were plotted to test for "outliers" and the need to transform the data. The tests were negative, so stepwise multiple regression was run on tree-value loss to see what variables in the study might be useful for predicting tree-value loss.

Dbh, merchantable height, their squares, square roots, and all

Table 2.—Mean dbh, merchantable height, butt-log grade, by sugarbush

Sugarbush	Dbh		Merchantable height		Butt-log grade	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
	- - - - Inches - - - -		*- - - - Feet - - - -*			
1	16.86	2.68	27.52	7.81	1.47	0.62
2	16.12	1.39	28.35	5.94	1.58	0.69
3	15.35	1.63	25.32	6.08	1.83	0.72
4	16.65	2.99	34.05	10.70	1.90	0.73
All sugarbushes	16.40	2.52	30.45	9.36	1.74	0.71

Table 3.—Mean value loss per tree and standard deviation within sugarbush

Sugarbush	Tree value[a] loss	Standard deviation
	- - - - - - - - - - Dollars	*- - - - - - - - - -*
1	2.75	1.87
2	0.68	0.61
3	4.39	1.66
4	3.64	2.91
All sugarbushes	2.87	2.38

[a] Based on $274/Mbf for No. 1 Common 4/4 hard maple lumber.

possible products of the dbh, merchantable height measurements were candidate predictor variables. Dbh was the only variable entered into the regression. However, the added precision with which sugarbush loss could be predicted with dbh was too small to justify any cost for collecting dbh data.

Mean and Variance of Value Loss

With no relationship between the tree value loss and measured tree characteristics, mean value loss per tree seems to be the best estimate of loss based on these data. Analysis of the between-bush and within-bush variance indicates significant inequality of variances between sugarbushes. Therefore, the simple mean of the four sugarbush means, $2.87, is the appropriate estimate of loss per tree, $\hat{V}$.

The value loss in a sugarbush can be estimated by $\hat{L} = \hat{V}\hat{N}$, where N is an estimate of the number of merchantable sugar maples in the stand. The variance of $\hat{V}$ can be estimated by $\mathrm{Var}(\hat{V}) = 3.770/\hat{N} + 1.897$ and the $\mathrm{Var}(\hat{L}) = \hat{N}^2\,\mathrm{Var}(\hat{V}) + \hat{V}^2\,\mathrm{Var}(\hat{N})$.
Then:

$$\hat{L} = \hat{V}\hat{N}, \text{ with } \hat{V} = 2.87 \qquad [1]$$

$$\mathrm{Var}(\hat{L}) = 3.770\,\hat{N} + 1.897\,\hat{N}^2 + \hat{V}^2\,\mathrm{Var}(\hat{N}) \qquad [2]$$

If the number of trees in the stand is known, rather than estimated, $\mathrm{Var}(\hat{N}) = 0$.

The differences between bushes resulted in the lack of precision with which the value loss can be predicted. However, the value loss—less than 5 percent of the overall mean tree value—is relatively small.

Untested variables may account for the large differences between stands. For example, sugarbush 2 may have been atypical because it seemed to have been tapped for only 3 years. One-third of the trees in this bush had no change in value after double grading. A more realistic estimate of value loss can be made by deleting the mean for bush 2. The estimate of variance however would retain the mean square error for bush 2. The new mean value loss, $\hat{V}$, would be $3.59 per tree instead of $2.87, with variance estimated using equation [2].

Estimates of factory-lumber value loss would be useful for stands of mature sugar maple being considered for conversion to sap production. This estimate is not a substitute for the thorough investment evaluation that should be done in deciding the potential for converting a maple stand to sap production. Factory-lumber value loss is just one of the components in this analysis. The loss also can be used as one component in a user fee if the stand is to be operated by another party.

Application

Theoretical Example

We estimated the timber-value loss of a forest stand of mature sugar maple, 12.5 acres in area, in northern Vermont. Early in its history, the stand was operated for sap production, but had not been tapped for at least 15 years and so, was similar in history and composition to the sampled bushes. Field data were collected with slight modification of the procedure outlined by Lancaster and his coworkers (1974). Ten prism points were systematically laid out, and a 10-factor prism was used to select sample trees.

The information needed to evaluate the loss due to tapping is an estimate of the number of sugar maple in the 12-inch diameter class and above in grade 3 or above,[1] and a measure of sampling error. However, the sampled trees were tallied by dbh class to estimate the potential number of taps available. Below-grade sugar maple meeting the minimum diameter requirement were also tallied by diameter class only for purposes of estimating the total number of taps available. A poor-quality timber tree is usually adequate for sap production and sometimes is an excellent sugar producer.

There were an estimated 686.25 trees with a variance of 2,861.46. Value loss expected from tapping this stand can be predicted by applying the tree value loss from Table 3. The result is obtained by multiplying the estimate of trees, $\hat{N} = 686.25$, times value loss per tree, $\hat{V} = \$2.87$, which equals $1,970 ± $959 (± one standard deviation). If the more conservative estimate of $3.59 is used for loss per tree, the value loss for the stand is $2,464 ± $965.

Example Stand Characteristics

The basal area of the stand in merchantable sugar maple in the 12-inch diameter class and above is 77 square feet; the mean stand diameter is 15.7 inches. The following schedule for tapping intensity was used:

Dbh class (inches)	*Taps*
12–14	1
16–18	2
20–24	3
26 and greater	4

The potential number of taps is 88.3 per acre. If cull trees are included, there are 95.1 taps per acre. The gross volume[2] of sawtimber is 7,826 board feet per acre. This is broken down by quality as 750 board feet per acre in grade-1 trees, 2,549 board feet in grade-2 trees, and 4,527 board feet in grade-3 trees.

Related Issues

The decision to convert a stand to maple sap production is a long-term management commitment. Timber production becomes a

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[1] The USDA Forest Service tree grades (Hanks 1976) are based on the USDA Forest Service log grades (Rast et al. 1973). The guide for hardwood tree grading used by Forest Service markers in Region 9 specifies minimum dbh based on Form Class 80.

[2] Volumes were estimated using a board-foot volume equation for sugar maple (Scott 1979).

subordinate goal because management for sap production requires (1) lower stocking to encourage wider and deeper crowns and (2) longer rotations because a tree continues to be a good sap producer long after it has passed the age of financial maturity as a timber tree, about 100 to 120 years.

To apply this evaluation, a potential sugarbush must be defined the same way we defined a sugarbush in the study. It should be a contiguous stand of mature sugar maple with minimal stocking for commercial production. Stands that do not qualify within the larger maple stand should be removed from the analysis. Maple stands that are not contiguous should be evaluated independently.

It is important to note that this evaluation of value loss included sawing the tapped zone into factory lumber. If, as has been done in the past, the butt log is cut above the tapped zone (jump-butt cutting), our estimate of value loss would be inappropriate. To ensure that the butt log is acceptable to the mill, use only plastic spouts for sap collection and use only aluminum nails to hold the pipeline in place at stress points.

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Guidelines for Evaluating Regeneration Before and After Clearcutting Allegheny Hardwoods

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Abstract

Use of the guides presented here will enable selection of Allegheny hardwood stands most likely to regenerate successfully after clearcutting. The guides are based on how well before-logging criteria predicted success in a number of stands 5 years after cutting. In comparison to earlier information, these guidelines recommend more small reproduction and higher quality, though fewer, stems of large reproduction. Guides to evaluate regeneration after cutting, based on both number and height of stems, are included also.

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Introduction

Regeneration requirements before clearcutting Allegheny hardwood stands were quantified first by Grisez and Peace (1973). These requirements were based on observations of regeneration in 65 stands scheduled for clearcutting and on the reexamination of those stands 2 years after cutting. They recommended that regeneration on a minimum of 10 randomly located plots be examined and each plot classed as stocked or not stocked. They defined a stocked plot as one having at least 15 black cherry stems or at least 80 stems of all desirable species[1] per 6-foot-radius plot. The stem counts included both seedlings and sprouts. If 70 percent or more of the plots were stocked, then the stand could be expected to regenerate successfully after clearcutting.

Marquis and others (1975) included this recommendation in a more detailed guide which prescribed the most appropriate treatment for cherry-maple stands depending on the regeneration potential. In determining this potential, they also recommended that some saplings and small poles of the slower growing tolerant sugar maple, beech, and hemlock be considered as large advance regeneration and that these stems be retained when the stand is harvested. This enables these species to compete successfully with the faster growing, less tolerant species, and both will be present in the main crown canopy of the next stand (Marquis 1981). Thus, adequate regeneration before clearcutting can be small advance regeneration only or a combination of these stems plus larger advance regeneration of saplings and small poles. The 1975 recommendations also increased the minimum number of regeneration plots to be examined from 10 to 20.

Many of the stands used by Grisez and Peace were reexamined again 5 years after cutting, and the data provide the basis for updating and improving the earlier guides to advance reproduction before cutting. The same data also have been used to develop a guide to estimate the success of the cutting in terms of the amount and size of the regeneration 2 to 5 years later. This report presents these revised regeneration guidelines.

[1]Desirable species include black cherry, sugar maple, red maple, white ash, yellow-poplar, cucumbertree, and red oak. In some locations, other commercial species such as beech, birch (yellow and sweet), basswood, oaks other than red oak, hickory, aspen, butternut, hemlock, and white pine may be considered in the desirable group.

Regeneration Before Cutting

To estimate the amount of advance reproduction needed to ensure successful regeneration, we first determined the regeneration success for a number of stands 5 years after cutting. Then, the before-logging inventories of advance reproduction were examined to see what combinations of species and number of stems best predicted success 5 years after cutting. Because advance reproduction of black cherry contributed so much to the success of the regeneration cuts, it was considered separately from the other desirable species. The criteria tested ranged from a combination of only 10 black cherry stems or 35 stems of other desirable species up to as many as 50 black cherry or 200 stems of all desirable species. They also considered the total number of stems regardless of species, acreage to be clearcut, and acreage of recent clearcuts in close proximity to the sample stand.

Of the many criteria considered, the most useful was the proportion of plots containing 25 black cherry stems or 100 stems of all desirable species. This criterion provided better results than the earlier criterion of 15 black cherry stems or 80 stems of desirable species:

	15/80 criterion	25/100 criterion
	percent	
Stands that met the advance regeneration criterion and could be clearcut	44	29
Proportion of the above stands that were clearcut and regenerated successfully	73	90

These data show that the 15/80 criterion permits clearcutting in a large number of stands that actually failed to regenerate (27 percent in this sample). The 25/100 criterion provides a much better success rate than all other criteria tested (only 10 percent failed). The 25/100 criterion is conservative because some stands that actually would regenerate do not qualify and therefore would not be clearcut. In such stands, we feel it is far better to use shelterwood cutting than to go ahead with clearcutting and risk failure.

In these tests, we used data for all seedling-size stems. However, in more recent studies, we have learned that seedling survival after clearcutting varies widely by size, age, and vigor. Seedlings over 6 inches tall with numerous leaves survive better than seedlings 2 to 6 inches tall. Seedlings less than 2 inches tall with fewer than 2 full-size leaves and seedlings that germinated in the current year survive poorly and should not be considered in regeneration assessments.[2]

For these reasons, we now redefine a stocked advance regeneration plot as one which has a minimum of 25 black cherry stems or a total of 100 stems of all desirable species less than 0.5-inch d.b.h. on a 6-foot-radius plot. In making this determination, do not count seedlings that are less than 2 inches tall, seedlings with fewer than two normal-size leaves or those that still bear cotyledons. Stems 2 to 6 inches tall with at least two normal-size leaves are counted in the usual manner. Stems over 6 inches tall with numerous normal-size leaves can be given extra weight. Count every two black cherry stems over 6 inches tall as three stems; count every stem of other desirable species over 6 inches tall as two stems. Thus, adequate stocking of advance regeneration may be achieved with fewer than 25 black cherry or 100 of other desirable species if some or all of them are large.

The requirements for large advance reproduction also are modified to be more stringent on tree quality and size but include fewer stems. To be stocked with large regeneration, a 6-foot-radius plot must contain one acceptable tree of sugar maple, beech, or hemlock 3 to 10 inches d.b.h. Acceptable trees have at least moderately good crowns and clean straight boles free of branches, epicormic branches, or other defects for at least the first 17 feet. Such trees usually survive and should develop into sawlog-quality trees in the future if left after cutting.

As in the past, at least 70 percent of the regeneration plots examined (a minimum number of 20 plots plus one additional plot for every 4 acres in stands over 20 acres) must be classed as stocked before successful regeneration of the stand can be expected. However, in stands where plots with large advance reproduction are included (and where this reproduction is to be retained after final harvest), at least 50 percent of the plots must be stocked with small advance reproduction and enough additional plots stocked with large advance reproduction to total at least 70 percent of the total number of regeneration plots.

Regeneration After Cutting

Guides to the amount of regeneration required at various ages after final harvest have never been developed specifically for the Allegheny hardwood type. The eastern region of the USDA Forest Service has used the rule that 70 percent of the regeneration plots (6-foot radius) examined must contain at least two stems of any height for the regeneration to be considered successful. Although this rule is probably acceptable in most areas, it is not adequate on the Allegheny Plateau where heavy deer browsing often destroys large numbers of seedlings. The two-stems-per-plot rule is applicable on the Plateau only if counts are limited to stems over 5 feet tall because these are assumed to have grown above the reach of deer. Therefore, do not consider regeneration after final harvest to be established in Allegheny hardwoods until at least 70 percent of the 6-foot-radius plots contain two stems over 5 feet tall. Most stands require 5 to 10 years to achieve this level.

To determine guides to the probable success of regeneration 2 to 5 years after harvest cutting, we examined the regeneration in 34 clearcuts at both 2 years and 5 years after cutting. We summarized the data using numerous stocking criteria, and then grouped the clearcuts into several categories. It was easy to determine those that were obviously successful (met all the criteria tried) and those that were obviously failures (failed to meet any of the criteria tested). But other stands were marginal, meeting some criteria but not others.

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[2] Marquis, David A. Effect of advance seedling size and vigor on survival after clearcutting. Northeastern Forest Experiment Station. In preparation.

The criteria tested included: (1) information on the total number of stems per plot, and (2) information on the number of stems over 3 feet tall. Both types of information are important. Field observations show that several years after clearcutting Allegheny hardwood stands, the presence of stems over 3 feet tall indicates that deer browsing is not so severe as to prevent some stems from growing. Although not yet out of reach of deer, there is reason to expect that some will reach 5 to 6 feet in height in the near future. Total number of stems is also important in young clearcuts or in older ones being browsed heavily. Very large numbers of stems, even small ones, provide hope that a few will eventually escape browsing.

We found the most promising criteria for evaluation of regeneration 2 to 5 years after clearcutting to be: (1) the proportion of 6-foot-radius plots having at least 25 stems, and (2) the proportion of 6-foot-radius plots with at least five stems over 3 feet tall.

These two proportions are determined separately, and both are recorded for each plot. Along with the proportion of plots stocked with two stems over 5 feet tall, they provide three separate criteria for evaluation of regeneration stocking after final harvest cutting. These criteria can be used in various combinations to evaluate regeneration success and the need for supplementary cultural treatment as the new stand passes through several characteristic stages of development, as follows:

Stage 1 generally occurs during the first few years after cutting, but may be extended to 10 or more years if deer browsing is severe. During this stage, the proportion of plots stocked with 25 stems total is higher than the proportion stocked with five stems over 3 feet or two stems over 5 feet, and this criterion should be used by itself to indicate ultimate stand stocking. The scarcity of stems over 3 feet or 5 feet is normal for the first few years after cutting, before the stems have had a chance to grow much. If the proportion of plots with 25 stems total remains higher than the proportions for the other two criteria for more than 3 or 4 years, this indicates that something (such as deer browsing) is preventing normal height growth.

Stage 2 generally occurs 3 to 5 years after cutting in stands not subject to excessive browsing or occasionally sooner in stands that had large advance seedlings prior to cutting. At this stage, a good many stems have grown over 3 feet in height and the proportion of plots with 25 stems total and the proportion of plots with 5 stems over 3 feet are both high. The average of these two proportions is the best indication of the ultimate regeneration stocking. At this stage, not enough time has elapsed for many stems to grow above 5 feet, and the proportion of plots stocked with two over 5 feet is lower than is the proportion of the other two criteria.

Stage 3 generally occurs from 6 to 10 years or more after cutting in stands not subject to excessive browsing. At this stage, many stems have grown over 5 feet and competition resulting from crown closure reduces the total number of stems present. At this stage, the proportion of plots stocked with two stems over 5 feet is higher than the proportion stocked with either of the other two criteria, and the stand is established.

Thus, the future stocking of the stand can be estimated at any time from the proper combination of stocking criteria. The impact of deer browsing is also evidenced by delays in the time required for the new stand to progress through the several stages of development.

Need for supplementary silvicultural treatment likewise can be determined from these stocking data. If the stand is progressing through the various stages of development in the expected time with at least 70 percent stocking, the probability of regeneration success is high and no special treatments are needed. If stocking with 25 stems total is at least 70 percent, but the stems are not developing in height, deer browsing is probably hindering their progress; fertilization or fencing should be considered. If none of the three stocking criteria exceed 50 percent, the stand has a poor chance of success and fencing should be considered. If none of the three stocking criteria exceed 30 percent, fencing, planting, fertilization, and weed control may all be required to establish a new, fully stocked stand.

New stands are considered to be established successfully only when at least 70 percent of the plots contain at least two stems of desirable species over 5 feet tall. The other criteria provide an indication of probable outcome, but stands are still in the process of regeneration until the stems grow above the 5-foot height.

All three stocking criteria should be determined both for desirable species alone and for all commercial species. This permits the success or probable success to be specified in terms of these two species groups. When 70 percent or more of the plots are stocked with two or more stems of any species over 5 feet tall, the stand should be considered established, even though it may not be 70 percent stocked with desirable species. Further change in stocking of desirable species is unlikely after the site is occupied by other stems of large size.

Tallies of all stocking criteria can be made simply by checking appropriate boxes on a simple tally form (Fig. 1) to indicate that a plot meets the particular criterion. Then the number of boxes checked divided by the total number of plots examined provides an estimate of the percent stocking for each criterion.

Figure 1. Regeneration Tally

Advance regeneration date ____

Criteria	Plot No. →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total	%
25 BC or 100 desirable spp	Small Regen																																
SM BEE HEM	Large Regen																																

Regeneration ___ years after logging date ____

Criteria	Plot No. →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total	%
2 stems at least 5 feet tall	Desirable Spp.																																
	All Comm.																																

At least 25 stems any height	Desirable Spp.																																
	All Comm.																																
At least 5 stems 3 feet tall	Desirable Spp.																																
	All Comm.																																

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